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done I cannot tell, for the cocoon of eggs seem to be attached to the spinneret. On the following morning a broad funnel-shaped rim was built around the tube but not yet covered; by the 24th she has made a room lightly covered with moss.

Rev. Dr. McCook kindly furnished cuts of the nest with the open funnel.. I append his description, which was published in the Proceedings of the Academy of Natural Sciences of Philadelphia: "The tube is about seven and one-half inches deep, resembling an ear-trumpet (Fig. 1), with the mouth upward. It is bent at an angle of 60° shortly below the surface; the upper part is a silk-lined funnel that widens outwardly to the margin which at the highest point is one and one-eighth inches above the surface of the ground. The silken lining extends but a little way below the surface. The projecting funnel is composed of blades of grass (Fig. 2), which are bent down upon their stalks from all sides, overlaid, and rudely interwoven, making thus a background upon which the smooth silken lining is placed. The longest diameter of the mouth of the tube (Fig. 1), *ab*, is one and one half inches, the shorter diameter *cd*, is one and one-quarter inches. The diameter of the tunnel below the surface is five-eighths of an inch."

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THE FORMATION OF CAPE COD.[1]

BY WARREN UPHAM.

THE peninsula of Cape Cod, called by Thoreau the "bended arm of Massachusetts," the Elizabeth islands, which are a continuation from it to the south-west, and Martha's Vineyard and Nantucket on the south, are recent additions to the territory of New England. They contain no ledges of solid rock, but are made up of the ruins and detritus of ledges which have been broken and pulverized. This has been done by decomposition under the influence of frosts and rains, by the excavations of streams, and at the last by glacial erosion. Materials have been thus gathered and mixed from sources near and remote. Their deposition, excepting the Tertiary beds of Martha's Vineyard, appears to have taken place during the Quaternary period, partly before the ice-sheet was extended over this region, partly along its terminal front in long series of morainic hills bordered on the south by sloping plains of gravel and sand, and partly by immense floods poured down from the surface of the melting ice-fields during their retreat.

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[1] A previous description of this region, based on observations made in a hasty journey for comparison of its drift deposits with those found in New Hampshire, was presented a year ago in the Geological Report of that State, Vol. III, pp. 300–305. Since that time the writer has been over this field more leisurely, spending several months in amateur exploration from Cape Cod and Nantucket westward to New Jersey. This has brought a more correct knowledge of the facts, especially in respect to the course, in South-eastern Massachusetts, of the series of hills here called terminal moraines; as well as some changes in opinions, one of these being in respect to the probable height of the sea here when these deposits were accumulated.

Since the glacial theory of the origin of the drift was brought to the attention of geologists by Agassiz, forty years ago, it has been closely compared with all the observed facts, and seems to afford for them an adequate and complete explanation. It has received the highest kind of testimony to its truth in being required to explain new discoveries and to answer questions which were not thought of when the theory was announced. The glaciers of Switzerland were found to furrow, scratch and polish the bed-rock over which they move, rounding and planing away its projecting points, just as the ledges of all northern countries are striated, rounded and worn smooth. This is done by the grating of boulders and gravel frozen in the bottom of the ice; and the sides of these stones are, of course, planed and striated the same as the underlying rock. In the valleys of the Alps are many glaciers ten to twenty miles long, and through this whole distance rock-fragments are dropped on them from bordering cliffs, brought in by tributaries and wrenched from the ledges beneath; so that diverse kinds, some of them derived from its farthest sources, become mingled both at the top and bottom of the ice. Corresponding to this transportation, grinding and mixture of materials effected by the glaciers, there was found over the surface of all regions which had striated ledges a most remarkable deposit of boulders gathered from distant and diverse sources, indiscriminately mixed with gravel, sand and clay. Many of these blocks and pebbles have their sides worn flat and marked with striæ, and were evidently the agents by which the ledges were similarly eroded and marked. This deposit, called unmodified drift or till, differs from any made by rivers, lakes or the sea, in showing no evidence of the assorting and stratifying action of water. To account for its formation and for the accompanying striæ on the ledges, it was supposed that a mantle of solid ice was accumulated over these areas, and that it moved slowly in the direction of the striation, ploughing up, transporting, grinding and mixing together the materials of the till, and leaving its track and course clearly marked upon the bed-rock.

Cape Cod is mainly composed of another formation, called modified drift, because it has been transported, worn and deposited by currents of water. Gravel, sand and clay are separated in distinct layers and beds, instead of being mingled in one mass. Most portions are entirely destitute of any large boulders, and the pebbles of the gravel are rounded, instead of the planed or else rough and unworn forms which they have in the till. The modified drift is found in the valleys or upon the nearly level tracts of glaciated regions, and follows lines of drainage which reach beyond these limits. Formerly it was the prevailing opinion that this formation was gradually produced from the unmodified glacial drift by the ordinary action of rains, streams and the sea. Further observation, however, seems to leave no doubt that it originated from the ice-sheet, and was rapidly deposited during its retreat. This had taken up in its lower portion not only boulders of every size, but also great quantities of decomposed rock, which covered the hills and plains and had been swept into thick deposits in the valleys before the glacial period. The rivers formed by its melting gathered such of these materials as they could transport, turned the blocks and pebbles over and over in their descent till they were made round and smooth, and deposited their freight in these beds of gravel, sand and clay. The modified drift of South-eastern Massachusetts, here to be described, appears to add much to our knowledge of these conditions attending the departure of the ice-sheet.

Another subject of great interest is presented on Cape Cod and the Elizabeth islands in a series of drift-hills, which appear to have been formed at the margin of the ice during a pause in its retreat, when, perhaps after some re-advance, it halted and preserved its termination nearly stationary through a long period. This series consists of very irregular hills, mounds, ridges and enclosed hollows, and is composed partly of till, with abundant boulders and no marks of stratification, and partly of stratified gravel and sand with boulders few or rare. That it does not indicate the extreme limit of glacial action is shown by the occurrence of a similar belt of hills on Martha's Vineyard and

Nantucket islands, from five to thirty miles farther south. A comparison of these with similar ranges of hills in Rhode Island, Long Island and New Jersey, which seem to be same series continued farther to the west, will enable us more fully to understand the meaning of these deposits.

The most noticeable product of a glacier is its terminal moraine, or the heaps and ridges of detritus which it brings down and pushes out at its end, when this remains at nearly the same place through a long succession of years. Slight advances and retreats often give these deposits a most broken surface of alternating hillocks and depressions, and in many cases they are partly composed of stratified gravel and sand, brought by streams during the meltings of summer. The great ice-sheets of the glacial period acted in the same way, and within a few years geologists have recognized the terminal moraines of that which overspread the Northern United States and British America. Across New Jersey[1] and upon Long Island[2] its outmost border is definitely marked by a continuous series of drift-hills, one hundred and seventy-five miles in extent. Striæ, till and boulders are confined to the region north of this line. From the Narrows to Montauk point this moraine is commonly known as the "backbone of Long Island," and consists of hills which vary from one hundred and fifty to three hundred and eighty-four feet in height. The west portion of this range, reaching from Fort Hamilton, by Greenwood cemetery, Prospect park and Ridgewood reservoir, to Roslyn, a distance of twenty-five miles, is mainly an unstratified deposit, like the loose, oxidized, angular upper till which forms the surface generally through New York and New England. From Roslyn, through the middle and east portions of the island, nearly all of these hills, including the highest elevations in the range, are composed of modified drift, being gravel and sand distinctly stratified and containing few or rare boulders. The part of Long Island south of these hills consists of gently sloping plains of fine gravel and sand, five to ten miles in width, and extending a hundred miles in length. The height of their upper margin at the foot of the hills varies from fifty to one hundred and fifty feet above the sea. Another long series of plains, varying from one mile to five miles in width, and of similar height and southward slope with the foregoing, extends on the north side of these hills from Syosset forty-five miles eastward to Riverhead, and thence continues along the north branch of the island nearly thirty miles more to Orient point. North of these plains, along the whole extent of shore east from Port Jefferson, is another series of drift-hills which rise one hundred to two hundred feet above the sea, by which their northern side has been frequently washed away. This second moraine is also mainly composed of stratified gravel and sand with few boulders; but in the vicinity of Greenport and Orient its material is changed to a very coarse unstratified deposit like the upper till. This series is very plainly continued north eastward in Plum and Fisher's islands, which are made up of hills of glacial drift like those near Greenport, with small areas of level modified drift at their south side. Thence it passes into Rhode Island at its south-west corner, and extends close to the coast seventeen miles from Watch Hill nearly to Point Judith, being very finely developed in a belt which varies from one-half mile to one and a-half miles in width, composed of coarsely rocky drift in hills and ridges one hundred to one hundred and fifty feet high. About two miles north-west from Point Judith this range sinks to the sea-level, and its further continuation is lost, probably because it turns southward into the ocean. Twelve miles to the south the continuation of the first range is lifted into view in Block island, a knot of very irregular drift-hills, which resemble those of Montauk in being composed of coarse gravel, sand and clay, distinctly stratified but often enclosing numerous boulders. We have thus two long parallel series of drift-hills, the most southern of them at the boundary of the glacial drift. Both appear to be terminal moraines of the ice-sheet, having been formed along its border, the southern range at its period of greatest extent, and the northern at some later time during which it halted in its departure.

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[1] Annual Report of the Geological Survey of New Jersey for the year 1877, pp. 9–22, with map.

[2] This series of hills on Long Island was well described by Mather in the Geological Report of the First District of New York, in 1843, shortly after the theory of continental ice-sheets was proposed.

The sea covers the next thirty miles in the line of continuation of these series of hills, beyond which both of them rise above its waves again, the northern forming the Elizabeth islands, and bending to the north-east and north on the peninsula of Cape Cod to near North Sandwich, where it turns at a right angle, and thence runs to the east through Barnstable and the other towns to Orleans, traversing the west-to-east portion of the cape, and extending into the ocean at its east shore. The southern moraine, marking the farthest bound reached by the ice, forms No Man's Land, the crest of Gay Head, and prominent ranges of hills in the north-western part of Martha's Vineyard, extending north-east nearly to Vineyard Haven. Here this series apparently bends to the south-east, somewhat as the northern range turns at North Sandwich, but it is concealed beneath plains or the sea for much of the way beyond this point. It appears unmistakably, however, on Chappaquiddick and Tuckernuck islands, and in Saul's hills and Sankaty Head on Nantucket. The length of the northern moraine from the east shore of Cape Cod to the west end of the Elizabeth islands is sixty-seven miles, while its total length to Port Jefferson, on Long Island, is about one hundred and eighty miles. That of the southern moraine, in its course from Sankaty Head to No Man's Land, is fifty miles, and its whole extent as yet traced, to the west line of New Jersey, is about three hundred miles.

On the islands south of Cape Cod these hills have the following heights in feet above the sea: No Man's Land about one hundred and fifty; Gay Head one hundred to one hundred and forty-five; about one mile east, near the church, one hundred and eighty-five; Prospect hill, the highest on Martha's Vineyard, two hundred and ninety-five; Peaked hill, a mile south from the last, two hundred and ninety; other hills, reaching from these five miles to the north-east, two hundred to two hundred and fifty; Indian hill, two hundred and forty-five; Sampson's hill, on Chappaquiddick island, about one hundred; highest part of Tuckernuck, about fifty; Macy's or Pole hill, the highest of Saul's hills, ninety-one; Folger's hill, a mile east from the last, eighty-eight, and Sankaty Head, the highest point of Nantucket island, one hundred and five. The cliffs of Gay Head, at the west end of Martha's Vineyard, expose a section four-fifths of a mile long, composed at the top of the unstratified terminal moraine five to forty feet thick, filled with abundant boulders of all sizes, up to twenty feet in diameter. This rests on fossiliferous Tertiary beds,[1] probably of Miocene age, which dip from 20° to 50° northerly throughout the section, and present a most striking succession of brightlycolored clays, sand and gravel, varying from black to red, brown, gray and white. Gay Head township, reaching three miles to the east, has a very uneven surface of glacial drift in small elevations and depressions, strown with frequent boulders but apparently underlain by Tertiary clay and sand at no great depth. The parallel ranges of hills which extend through Chilmark and the north-west part of Tisbury, occupying a width of one to three miles, have also a very irregular contour. Their surface is generally glacial drift with very abundant boulders, but occasionally, as at the top of Prospect hill, it is modified, consisting mainly of water-worn gravel and sand. The black, red and white Tertiary clays underlie these deposits in the hills, and are exposed in the cliffs along the north-western shore to the east side of Lumbard's cove, eleven miles from Gay Head. Upon the south side of Prospect and Peaked hills they extend to heights two hundred and twenty-five and two hundred and fifty feet above the sea.

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[1] Described in Hitchcock's Geology of Massachusetts, 1833 and 1841; and in Lyell's Travels in North America in 1841-2, Vol. 1, pp. 203-206.

The south-eastern half of Martha's Vineyard consists of modified drift without boulders, lying in extensive level plains twenty-five to fifty or sixty feet above the sea. Along the south shore these plains are indented by numerous ponds, which are only separated from the ocean by a beach, and the shores of the ponds are again indented by long and narrow arms or coves, from the head of which dry channels extend across the plains in a northerly course. The road from West Tisbury to Edgartown crosses several of these depressions, one of which, known as Quampachy hollow, may be taken as an example; this starts from the head of Oyster pond, a narrow arm of the sea which stretches two miles north from the beach by which it is now shut in. The dry hollow, diminishing from twenty-five to ten feet in depth and from three hundred to one hundred feet in width, prolongs this valley at least three miles to the north. Near Vineyard Haven and Oak Bluffs, north of these plains, and on Chappaquiddick island, the modified drift, sometimes sprinkled with boulders, is heaped in gently-sloping hills fifty to one hundred feet high, which appear to have been formed at the margin of the ice-sheet. Thence the line of terminal moraine is continued in Muskeget and Gravelly islands, which, however, are only low banks of gravel and sand. On Tuckernuck island it appears again in small hills, which in part, as seen at North pond and eastward, are unstratified, with plenty of boulders, the remainder being modified drift.

Nantucket is almost wholly composed of stratified gravel and sand. Along the whole south side of the island, from Long pond to Tom Never's Head, these lie in nearly level plains, twenty to sixty feet above the sea. This expanse, reaching more than ten miles from west to east, with a width varying from one to three miles, is broken by frequent hollows which extend approximately from north to south like those already noticed on Martha's Vineyard. Narrow ponds, of the same height as the ocean, fill the entire course of these depressions, or occupy their lower end next to the beach. All the ponds along the south shore are of this class, including Long, Hummock, Miacomet, Weweeder, Nobadeer, Madequecham, Wigwam and Forked ponds, with several others of smaller size. The line at which the ice-sheet appears to have terminated is marked in the west part of the island by gently undulating hills, forty to fifty feet high, composed of stratified drift, which, however, differs from that of the plains in having here and there boulders up to ten feet in diameter embedded in it or lying on the surface. The course of this line is from Eel point, north of Maddequet harbor, by Trot's hills, to the town. Eastward it continues on the same course in the Shawkemo hills and Saul's hills to Sankaty Head. The portion of this series called Saul's hills, two miles long and a half mile wide, is of very irregular contour, with steep and abruptly-changing slopes, forming hills, ridges, mounds and small enclosed basins, some of which contain ponds. The material is stratified gravel and sand, upon and in which are scattered boulders, varying up to ten feet in diameter.

Sankaty Head, at the east shore of the island, affords a section across this range.[1] A quarter of a mile south from the lighthouse, the order of deposits, beginning at the base, is as follows: brown sandy clay to about twenty feet above the sea; ferruginous sand and gravel, four feet; white sand, four feet; yellow sand, enclosing masses of blue clay, one foot; ferruginous gravel and sand, with abundant shells, two feet; a bed of Serpulæ mixed with sand, about two feet; gravel and sand again, thickly filled with shells, two feet; fine white sand, about ten feet; the common yellow sand and fine gravel of the modified drift, about forty-five feet, its top being at ninety feet;

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[1] The Post-pliocene beds at the base of this section, and their fossils, are fully described by Prof. A. E. Verrill and Mr. S. H. Scudder, in the *American Journal of Science and Arts*, 3d series, Vol. x, pp. 364–375.

coarse gravel, three feet; ferruginous sand, one foot, changing above into a former surface soil one foot thick; overlain by three feet of dune sand, which forms the present surface ninety-eight feet above the sea. The highest part of the bank is midway between this point and the light-house. On each side of the section here noted the shell-beds gradually thin out and disappear at a distance of about forty feet. The bed below the layer of Serpulæ contains about thirty-five species, which make up a faunal group of distinctly southern character, all of them being now found living on the southern shores of New England, but several having their northern limit at Cape Cod. The species of Serpula is also of southern range, reaching from this limit to North Carolina. The upper shell-bed has about the same number of species as the lower, but only thirteen are common to both. The new species brought in by the upper bed are mostly of northern range; though all of these are found as far south as Massachusetts bay, several of them have their southern limit here or on the south coast of New England. From a comparison of these groups, Prof. Verrill estimates that the average temperature of the sea at this place had been lowered 15° between the times in which they lived. The layer of coarse gravel which occurs here at the height of ninety feet, is continuous for a half mile from this point, both to the north and south, varying from three to eight feet in thickness. About half of its rock-fragments are rounded, these being of all sizes up to one foot through; the rest, which are rough and angular, range up to two feet and rarely to four feet in diameter. This bed has its greatest thickness and is coarsest at the highest portion of the bluff, where it closely resembles till. The old surface of black soil and the present surface of dune sand are also continuous along the same distance, the latter at the light-house and northward being one and a half feet thick. An eighth of a mile south from the shell-beds the bluff falls to a hollow about sixty feet above the sea, and in this depression the blackened layer becomes a bed of peat two feet thick, containing numerous stumps and roots of trees and covered by two feet of sand. The rocky stratum, the old surface soil and the overlying sand cap the bluff for more than a mile, in which its height falls from one hundred and five feet at the middle to about thirty-five feet at each end. Below the rocky layer it consists of fine modified drift and pre-glacial beds. The history of this section reaches from a period when the sea had about its present temperature; next it becomes much colder; sand and fine gravel are accumulated to a depth of more than fifty feet, probably brought by rivers from the summer meltings of the ice-sheet; this finally reached its outmost limit, overspreading the north half of the island; at its retreat the coarser materials which it held were dropped; forests sprang up as the climate became mild again; and lastly, the sea has eaten away the east portion of these deposits, while the sand of its shore has been swept by the wind over their top.

Heights of the later terminal moraine, on the Elizabeth islands and Cape Cod, are as follows; highest portions of Cuttyhunk, Nashawena, Pasque and Naushon islands, about one hundred and seventy-five feet above the sea; the Quisset hills, west of Falmouth village, about one hundred and fifty; station of the U. S. Coast Survey, one mile east of West Falmouth, one hundred and ninety-eight; the Ridge hills, extending thence to the angle of this series near North Sandwich, one of them being called Pine hill on the State map, one hundred and fifty to two hundred feet; south-west from Sandwich village, about two hundred and twenty-five; Bourne's hill, a Coast Survey station two miles south-south-east from Sandwich, the highest point of the whole series, two hundred and ninety-seven; the Discovery hills, including the last and extending eastward, two hundred and fifty to one hundred and fifty; Shoot Flying hill, one-half mile north-west from Great pond in Barnstable, about two hundred; German's hill, in Yarmouth, one hundred and thirty-eight; Scargo hill, in Dennis, one hundred and sixty-six; railroad summit at Brewster station, one hundred and twenty-five, and Mill hill, in Orleans, about one hundred and fifty.

This moraine forms the entire chain of the Elizabeth islands, fifteen miles long with an average width of one mile. Their contour throughout is very irregular, with no well-marked trend of the elevations, which are roughly outlined hills and ridges of variable height, enclosing many crooked and bowl-shaped hollows which often hold small ponds. Their material is glacial drift with abundant angular boulders of all sizes up to twenty or thirty feet in diameter. In a few places this unmodified till was seen enclosing or passing into stratified gravel and sand. The surface exhibits all the characteristic features of the upper till, being loose, yellowish in the color of its detritus, and with its boulders almost invariably angular except as they have been rounded by exposure to the weather. This deposit also appears to form the greater part of the cliffs upon the shores of these islands. At the north-east end of Naushon, however, in deepening an old well, from forty-five to sixty-seven feet, only the dark and compact lower till, or ground moraine, was found.

The trend of this chain of islands is about east-north-east, but on the peninsula of Cape Cod the same belt of hills, continuing with its width, contour and material unchanged, bends within a few miles to a course nearly due north. A railroad cutting thirty feet deep in these deposits, near Wood's Holl, and shallower sections on the Quisset hills, show two or three feet of yellowish till at top, succeeded below by light gray till, equally coarse but apparently more compact, with some of its fragments planed and striated. The latter was probably accumulated beneath the ice-margin, while the former was dropped by its meltings.

After holding its way northward ten or twelve miles, reaching to a point about a mile south of North Sandwich, the range turns at a right angle to a course a few degrees south of east. Some portions of it in this vicinity are strown with boulders; but mainly, as shown on the roads which cross these hills south-west and south from Sandwich village, at the highest portion of the entire series, they consist of stratified gravel and sand with boulders rare or entirely wanting. There is also a change to a more simple contour with fewer irregular hills and hollows.

From its angle the range extends about thirty-five miles to the east shore of the Cape. Through Sandwich and Barnstable it lies about a mile south of the railroad, consisting in the latter town of hills one hundred to two hundred feet high, apparently formed of modified drift, with frequent boulders embedded in it and scattered upon its surface. In Yarmouth the series is somewhat broken, and the railroad crosses it upon a sand plain a little west of German's hill. South of Dennis pond and for one and a half miles north-east from German's hill to Follin's pond, it is very well shown in exceedingly rocky low hills. Next it appears to suffer an offset of about two miles to the north, being represented by Scargo hill in Dennis, which is modified drift with only few boulders. Thence it runs a little north of east six miles to Brewster station, where it is again crossed by the railroad.

Through most of this distance it is very rocky, some of its blocks being twenty to thirty feet or more in diameter. Its further course is mostly modified drift with occasional boulders, passing east-north-east to Mill hill, Orleans village, and the south-east side of Town cove, beyond which it is concealed beneath the ocean.

The conclusion of Mr. Clarence King,[1] that Naushon island which he examined, forms part of a terminal moraine of the continental ice-sheet, seems to explain the accumulation of this remarkable series of hills. The border of the ice, after falling back from its farthest limit, stopped at this line or re-advanced to it, and afterwards remained nearly stationary through a long period, in which the materials that it contained were being continually brought forward and deposited. In many places these would be pushed into very irregular heaps and ridges by slight retreats and advances of the ice margin. At the same time we should also expect that thick beds of ground moraine would be gathered beneath the ice near its termination. The withdrawal of the ice-sheet would then leave these deposits as upper and lower till, one overlying the other in a long but broken and undulating range.

The angle of this range at North Sandwich shows that the portion of the ice-sheet on the west and that on the east pushed against each other here, the motion and slope of each being directed toward its line of frontal moraine. The medial moraine produced where their slope came together north from the angle of their terminal line, is presented in Rocky, Manomet and Pine hills, which form a gigantic ridge in the east part of Plymouth, four miles long from north to south, with a continuous height three hundred to four hundred feet above the sea. Abundant angular boulders of all sizes up to twenty feet in diameter strew its surface. At the north end of this ridge the sea has undermined its base, forming a steep slope sixty feet in height. A section here showed twenty feet of upper till, yellowish, with abundant large and small boulders, nearly all of them angular, underlain by lower till, dark bluish gray, with small glaciated stones, exposed for twenty feet vertically but concealed below. The bed of boulders which forms the shore at this point came mostly from the upper stratum, and their sharp corners and edges have since been worn away by the waves.

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[1] Proceedings of Boston Society of Natural History, Vol. XIX, p. 62.

Besides the till, or boulder-drift, it has been stated that stratified gravel and sand, nearly or quite free from boulders, make up a large part of these series of morainic hills, including their highest portions on Long Island and Cape Cod. We thus see that the ice was aided in the accumulation of its terminal deposits by streams laden with vast quantities of modified drift. These streams appear to have been formed during the meltings of summer upon the surface of the ice-fields, especially at the period when they yielded and were driven back by a warmer climate.

To understand how such rivers could get their freight of gravel, sand and silt, we must consider what the ice-sheet was. The interior of Greenland is now covered by a similar field of ice, which rises steeply at its edge, but after a few miles changes to a gently inclined plateau, elevated above the highest peaks of the land on which it lies, and apparently of immeasurable extent. Dr. Hayes found the angle of ascent on this plain to decrease from six to two degrees in thirty miles, at which distance he reached an altitude of about five thousand feet. The ice of the glacial period had a similar, but probably less steep, ascent from its terminal front northward. The temperature of its area was changed so that the snows of autumn, winter and spring were not entirely removed in summer, but very slowly increased in depth, their lower portion being changed to solid ice. This continued through so long a period that the surface of this ice-sheet was lifted above the highest mountains of New England. At the White mountains, two hundred miles north from its border, it rose to a height at least 6300 feet above our present sea-level. Its greatest thickness was far to the north, from which region the vast pressure of its own weight caused it to flow slowly outward. Even its lower portion, which rested on the uneven surface of the land was thus pushed forward over all our hills and mountains, transporting boulders and marking its course on the ledges. Over British America, as far north as the surface geology has been explored, and to the most southern limit reached by the ice-sheet, which coincides nearly with the course of the Columbia, Missouri and Ohio rivers and the south coast of New England, the direction of its motion, as shown by the striæ, was generally southward, being nearly due south in British Columbia, south-west in the region of the great lakes, and south-east between Hudson river and the Gulf of St. Lawrence. The loose materials which covered the land were ploughed up, and as the ice moved forward over the irregular surface, it became more or less filled with boulders, gravel and sand, at least to the height of the peaks and ridges which it crossed. Differences in the slope of the surface of ice above, like those which made an angle in the terminal moraine, due apparently to inequalities in the amount of snowfall and of melting upon adjacent regions, must also produce downward and upward currents by which these materials would be distributed throughout the lower part of the ice, probably to the height of several hundred feet, even while crossing a nearly level area.

By the melting of the ice-sheet at and near its terminal front, this detritus was exposed, through every summer, to the washing of many rills and small streams; but before its retreat under a change of climate, this melting was extended over a very wide area. The surface of the ice was then hollowed into basins of drainage and channelled by rivers, which became heavily freighted with the gravel, sand and clay that had been held in its mass. A large portion of this gravel and sand was heaped at the edge of the ice-sheet, where these glacial rivers descended to the lower open area beyond. When the ice behind them disappeared these deposits were left in the massive hills and ridges of stratified drift which form so prominent a part of these series of terminal moraines. [*To be Continued.*]

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THE GEOLOGICAL MUSEUM OF THE SCHOOL OF MINES, COLUMBIA COLLEGE.

BY ISRAEL C. RUSSELL.

AS it is impossible for every one to visit distant lands, or even at all seasons to go forth into the fields and among the mountains in quest of geological knowledge, we desire to call the attention of our readers to a collection in our country which in a great measure will supply these wants. We refer to the Geological Museum under the direction of Prof. J. S. Newberry, at the School of Mines, Columbia College, New York city. Here the visitor will find a most interesting display of the remains of the ancient inhabitants of the globe, gathered not only from the rocks of our own country, but also from the most distant lands, and each arranged in its proper place in the long series.

The geological museum occupies the entire third story of the